Streambank stabilization, streambank fencing, nuisance species control, riparian zone management

The Costs of Restoring Anadromous Fish Habitat: Results of a Survey from California

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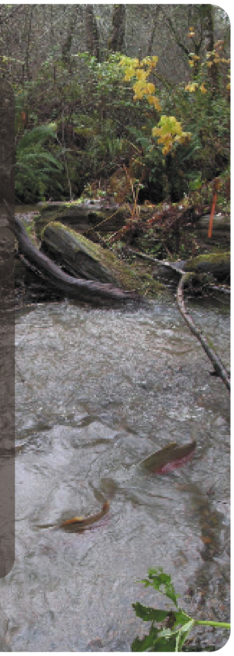

ABSTRACT

This study reviews 60 restoration projects designed to improve anadromous fish habitat in coastal California streams. These projects are broken down into three categories: those designed to create aquatic habitat through instream structures, those designed to improve the canopy through riparian plantings, and those designed to decrease erosion through bank stabilization. The cost data are analyzed for all the projects. The instream structure projects are analyzed in greater detail. The results suggest that the cost per stream mile for such projects may not be correlated with stream gradient, but are, as expected, correlated with the number of instream structures per mile.

INTRODUCTION

A wide variety of river corridor restoration projects are employed to improve habitat for fish and the organisms they depend on for survival. These projects include the creation of instream structures, the enhancement of riparian vegetation to increase the canopy over a stream, the implementation of bank stabilization strategies to decrease erosion, the removal of fish barriers, the creation of jump pools, and the creation of more large-scale watershed management plans to improve overall stream health.

This study is aimed at examining restoration projects that specifically benefit instream biota. Thus, watershed management plans and riparian restorations that involve large tracts of habitat away from streams (as opposed to streamside vegetation for stream shading) are not included here, as they benefit a wealth of other biota outside the stream. This study focuses only on the first three types of restoration projects: instream structures, streamside vegetation to increase canopy, and erosion stabilization.

All projects possess certain site-specific aspects that make them, and their costs, unique and difficult to compare. Thus, a large sample size is required to minimize this factor. With regard to the creation of jump pools and the removal of fish barriers, site-specific characteristics are especially important. This fact, combined with a rather small sample size, caused these types of projects to be removed from this study.

Beginning in 1981, the California Department of Fish and Game (CDFG) issued grants and solicited restoration projects under the Fishery Restoration Grants Program that were designed to protect, improve, and restore habitat for anadromous fish in the North Coast area of the state. In recent years, this program has been administered by the Native Anadromous Fish and Watershed Branch and has benefited from greatly increased funding. This study examines 60 completed projects for which there were sufficient data to analyze the cost per stream mile for each project. These projects are located along the north coast of California, primarily in Humboldt and Mendocino Counties. These streams provide habitat for steelhead, coho and chinook salmon, and coastal cutthroat trout.

While there is much literature to guide and analyze the implementation of restoration projects from a biological and hydrological perspective, there is little available information regarding the costs of restoration. However, cost data are increasingly important to obtain in light of natural resource damage assessment (NRDA) guidelines recently promulgated by the National Oceanic and Atmospheric Administration. These guidelines recommend that the costs of restoration be used as the basis for calculating natural resource damages to habitats injured by pollution events. In large damage claim cases, specific restoration projects may be identified and their costs estimated. However, in smaller cases, the desire to reduce assessment costs and the time until settlement of damage claims may require the use of default or generic restoration costs. In such cases, the results of this study may provide a basis for such cost estimates.

It should be noted here that the cost data used in this analysis do not include budgets for oversight by the Trustee agency (CDFG), monitoring of the success of the project, or long-term maintenance. Also, some of the planning costs and time dealing with permitting was borne by CDFG.

INSTREAM STRUCTURES

Instream structures are widely used to improve habitat for anadromous fish in cold water streams. Such structures may include the construction of boulder clusters, weirs or sills, log shelters and other types of cover structures, and other actions designed to improve stream habitat. We examined a sample of 37 projects that created cover structures.

Table 1 provides a summary of the data from these 37 projects. The gradient data

Table 1. Summary data regarding cover structure projects (n = 37)

	cost	stream length (ft)	# of structures	cost per stream mile	structures per mile	gradient (ft/mile)
Average	$20,693	5,996	15.5	$25,277	19.7	191
Median	$18,150	4,900	12.0	$20,835	12.1	155
St. dev.	$12,926	4,613	11.5	$16,256	19.5	166
Max.	$57,658	24,380	60.0	$70,754	96.0	728
Min.	$4,925	1,100	1.0	$5,638	1.3	25

were difficult to obtain and may include some erroneous estimates because many of the project reports lacked a detailed map of the project site and location. In these cases, the exact site and thus the gradient had to be estimated from topographical maps and the available information in the project report.

It was hypothesized that restoration costs per stream mile would be higher on streams with a steeper gradient because a greater number of instream structures would be needed to enhance habitat. An alternative hypothesis is that streams with steeper gradients are more likely to already have sufficient natural instream structures and, due to more difficult human access, may be less disturbed. Plotting the costs per stream mile against the stream gradient for the projects demonstrates little correlation. The correlation coefficient is -0.19. The negative correlation may be explained by the fact that the number of instream structures was negatively correlated with stream gradient (corr = -0.23).

Plotting the costs per stream mile against the number of structures per stream mile, however, yields a strong positive correlation of 0.64. The average cost per structure was $1,762, with a standard deviation of $1,270. The median was $1,444. This relationship is expected, of course, as it is the structures that generate much of the restoration costs.

Another hypothesis is that there are returns to scale in implementing restoration projects. Given a certain amount of fixed costs, the average cost per stream mile may decrease as project length increases. Indeed, this seems to be the case, as cost per stream mile was negatively correlated with the stream length of the project area (corr = -0.43).

However, this simple correlation does not convincingly make the case of increasing returns to scale, as the number of structures per stream mile was also negatively correlated with stream miles (corr = -0.41). The question thus becomes, does the cost per stream mile fall as the project length increases simply because of increasing returns to scale, or because the number of structures per mile falls as project length increases?

A multiple regression analysis was conducted to answer this question, regressing the costs per stream mile (the dependent variable) against stream gradient, the number of structures per mile, and the stream length of the project (the independent variables) (Table 2). Note that the resulting independent variable coefficients from a multiple regression (ordinary least squares) are essentially correlation coefficients but with the other independent variables held constant. Thus, we can examine the relationship between restoration costs and size with the number of structures per stream mile and stream gradient held constant.

The R-squared statistic is a measure of the overall fit of the model. It implies what percentage of the change in cost per stream

Table 2. Multiple regression results

Independent Variable: cost per stream mile   Number of Observations: 37
Degrees of Freedom: 33   R Squared: 0.46

Dependent variables	Constant	Stream gradient	Structures per mile	Stream length (ft.)
Coefficient	24,482	-0.88	427	-65,568
T-Statistic	1.93*	-1.67	3.42**	-0.91

* significantly different from zero with a 95% level of confidence   ** significantly different from zero with a 99.5% level of confidence

mile can be explained by the dependent variables. The R-squared statistic of 0.46 is relatively good, considering a cross-section analysis with only 33 degrees of freedom.

The coefficients may be interpreted in the following way. The constant suggests a starting point, that stream costs are $24,482 per mile, with adjustments to be made according to the coefficients of the other variables.

The coefficient for stream gradient is negative, implying that costs rise as gradient falls, all other variables held constant. This result seems counter intuitive and may be erroneous, a result of the small sample size and poor quality of the gradient data. Note that, with a low t-statistic of -1.67, it is not statistically different from zero with a high level of confidence.

The coefficient for structures per stream mile is highly significant and implies that each structure per mile is associated with an additional $427 in project costs per mile. Using the median of 12.1 structures per mile, this results in a total of $5,167 additional cost per mile.

The t-statistic associated with stream length implies that the coefficient is not significantly different from zero. The fact that this coefficient is not significant leads us to reject the hypothesis that there are increasing returns to scale associated with larger projects, regardless of the number of structures per stream mile. There do not appear to be increasing returns to scale. Note, however, that the range of projects examined in the data vary from 1,100 feet long to 5,996 feet long. It may be that this sample size did not include a wide enough range in the size of projects to detect increasing returns to scale.

Using only the most significant variables, the constant and the number of structures per stream mile, the resulting equation may be expressed:

$$\text{Cost per stream mile} = \$24{,}482 + \$427^{*}\ (\text{\# of structures/mile})$$

In a NRDA utilizing Habitat Equivalency Analysis (HEA), the size of the restoration project is known, as it is scaled during the exercise. If a specific restoration area is identified and the number of structures per stream mile can be estimated, the equation above may be used as a reasonable cost estimate of the proposed project. However, if the specifics of the project are not known, one may instead rely on the sample average ($25,277) as the estimated cost per stream mile. Note again that the complete costs for planning, trustee oversight, monitoring, and permitting are not included in these data.

STREAMSIDE VEGETATION

Eleven of the projects examined focused primarily on improving stream shading via riparian restoration immediately adjacent to streams. Extensive riparian restoration projects aimed at developing or enhancing riparian vegetation well removed from streams (such that the plantings would be too far from the stream to provide a shade canopy over the stream) were not included in this sample. The projects in the sample included such activities as alder planting, willow sprigging, and exclusionary fencing.

Table 3 provides a summary of the data from these 11 projects. Compared to the instream structure projects, these projects tended to be less expensive, with an average cost of $13,693 per stream mile. Note the wide range in costs per stream mile, reflective of the difference between projects requiring irrigation or the planting of more mature trees versus simple willow sprigging. The average cost may be applicable in HEAs regarding injuries to relatively flat lowland streams, where instream structures may be less relevant, but stream shading is important.

The other primary difference between these projects and the instream structure projects is the length of stream targeted by

Table 3. Summary data regarding streamside vegetation projects (n = 11)

	cost	stream length (ft)	cost per stream mile
Average	$14,068	12,899	$13,693
Median	$9,800	8,505	$13,030
St. dev.	$11,183	11,910	$13,541
Max.	$41,959	36,960	$47,530
Min.	$4,700	1,200	$1,047

the projects. Streamside vegetation projects averaged over twice the length of the instream structure projects.

EROSION CONTROL

Twelve of the projects examined focused on erosion control through various bank stabilization techniques. These activities often included riparian planting (in terracing) or elements similar to instream structures, but generally required more labor and materials, as reflected in the costs.

Table 4 provides a summary of the data from these 12 projects. These projects were far more expensive than the others, with an average cost of $43,620 per stream mile. Note again the wide range of costs per stream mile, again reflecting the wide range of applicable erosion control techniques. These projects also focused on very long stretches of stream, averaging over four miles in length.

CONCLUSION

It is often said that restoration projects are highly variable, with each project subject to a unique set of problems and obstacles at the project site. This variability is reflected in the data summaries, where wide ranges of costs are evident. Understanding actual restoration costs requires understanding this variability and minimizing it. It is thus best handled by either dividing up the projects into more types, based on project characteristics, or by obtaining large sample sizes where the variation can be overwhelmed by the average. Because few databases of restoration costs exist, and details regarding project characteristics or unique attributes are not readily accessible, accomplishing either task

Table 4. Summary data regarding erosion control projects (n = 12)

	cost	stream length (ft)	cost per stream mile
Average	$27,473	21,866	$43,620
Median	$21,391	4,490	$24,811
St. dev.	$14,255	39,985	$41,527
Max.	$49,942	132,000	$122,941
Min.	$7,265	1,585	$882

to reduce sample variability is difficult. Nevertheless, this presentation of cost data should assist restoration planners as well as those engaged in restoration-based natural resource damage assessments.

COMMENTS

It should be noted that, during the presentation of this information at the Habitat Restoration Cost Workshop, it was pointed out that the costs of these projects may be significantly underestimated for two reasons:

1. The labor costs in these projects are substantially lower than for similar projects in other states. In one example labor wage rates were ten times higher than in one of these projects.

2. These costs do not include planning, design, and permitting. In Idaho (on larger streams), this element has accounted for over 50% of total costs.